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Mr. K. BURTON is home from British Guiana.

Mr. M. D. G. CAMPBELL has returned to Persia.

Mr. A. F. CASTLE has left for Venezuela.

Mr. J. J. G. CLARK has left Rumania and is now in Holland.

Mr. W. ENGLISH is home from Egypt.

Mr. G. A. F. GRINDLE has left for Burma.

Mr. F. SAGER has returned to Italy.

Mr. H. TEMPLE WATTS has left for Iraq.

Mr. W. G. WEEKS has left Trinidad and is now in Venezuela.

The Secretary would be glad to hear of the whereabouts of the following members: — C. A. BAUDUIN, A. E. O. COOKE, J. M. DALZELL, W. J. HARRIS, L. B. HOLLOWAY, C. E. JOBLING, W. R. MACDONALD, Major E. T. NEWTON-CLARE, A. F. C. PARKER, NAND LAL PASI, W. E. SHEPHERD, E. V. SWAIN, R. K. VAN SICKLE, F. E. G. WATSON and A. O. WESTWOOD.

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THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

RUMANIAN BRANCH.

FOURTH ANNUAL DINNER.

THE FOURTH ANNUAL DINNER of the Rumanian Branch of the Institution of Petroleum Technologists was held at the International Club, Ploesti, on Friday, January 16th, 1931. Mr. J. L. Chaillet took the Chair, and about 75 Members, Guests and Friends were present.

Mr. J. L. Chaillet conveyed a hearty word of welcome to those present and said he would like to adhere to the custom of drinking the health of the King of Rumania, the country whose hospitality those present as foreigners enjoyed. All present then drank to the health of the King of Rumania and the Royal Family.

"The Rumanian Petroleum Industry."

Mr. F. W. Penny, in proposing the toast of the Rumanian Petroleum Industry, said: The feeling that is uppermost in my mind is that, although we are a Technical Institution, any consideration of the Rumanian Petroleum Industry this year must involve economic rather than technical questions. If we Technologists would serve our Industry well, we must not only be competent Engineers, Geologists and so forth but must also have an appreciation of what may be called the "Bankers" point of view. Therefore no excuse is needed for considering primarily the economic aspect of our great Industry this evening. The fact that our Industry is now international, and that the present crisis in it is world-wide, makes it impossible for us in Rumania to solve our difficulties by ourselves. The fact that the tendencies of two years ago foreshadowed the coming of such a crisis has not assisted us to meet it.

An Industry justifies its existence by paying dividends to the shareholders who have invested money in it. It does not exist as a philanthropic institution to sell its products for less than the cost of production plus distribution, nor does any reasonable person expect it to. In times of stress good management of good properties will make profits; but the two are often not combined.

Our task is certainly hard; as an example, in the United States a price of 60c. a barrel for crude is considered ruinous; our present price of 3000 lei a car is equivalent to 26c. a barrel—less than half—so that although the crisis is world-wide, there would seem to be something we can do to relieve the situation locally.

We are facing a situation unknown before in our business, that is a declining demand for our products. But we are fortunate in being producers of a raw material for which a substantial demand must exist if civilisation is to proceed normally, that is the power required for all forms of mechanical transport. Such a decline in demand as there now is would scarcely have been sufficient to disorganise our Industry had it otherwise been in a stable position, even in a period of general business depression. And it is recognised by everybody that the cause of this instability is over-production. We are bound by economic laws: the price of crude is depressed, and this gives the refiners a too cheap raw material and enables them to market their products below the cost of production plus refining. Under a continuance of this condition the independent producer must eventually drop out of the business, and the cycle will automatically adjust itself. But that is not the way to stabilise the Industry—by ruining half the people engaged in it. So let us consider the question from another angle.

Because our Industry has become international, a crisis in one area makes its influence felt everywhere. The old conviction that it did not matter how much oil we produced here so long as the Industry as a whole restricted its output, is no longer tenable. Two years ago it was arguable that, as the production of Rumania was being readily absorbed by its local and Central European markets, restriction need only take place elsewhere, that is to say where production could not be locally absorbed. But to-day Rumania has increased its production to far more than can be absorbed by its economic marketing area. Increase of local consumption has been retarded by the slow development of the purchasing power of the peasant. So Rumania must now restrict just the same as California or Venezuela. By reducing production, so that there is no excess over need, the manufacturer will no longer get a too cheap crude, and prices of products will be stabilised.

Rumania has recently attained a major position in the Oil Industry, both by reason of its large production and of the efficiency of its foreign marketing organisations. It consequently has acquired also responsibilities; but at the present moment it is the only major Oil Country in the world, outside Russia, which is disturbing the restriction of oil production—a very serious matter. Restriction means sacrifices for everybody: some drilling plant lying idle, refineries working at less than full capacity, a slower turnover of capital. We hope these sacrifices will be compensated by a stabilised and profitable price for our products. But in the United States, where restriction has been in force longest, the results at first sight are disappointing: the statistical position does not appear to wield any continuous influence on the price structure, and

producers have found that, notwithstanding their achievement of a 16 per cent. reduction, the price of crude continues to drop and the prices of products do not rise. They therefore are not even yet securing a proper return for their energies and risks. And the same thing may happen in Rumania, because it will take some months of restriction to rectify the present over-production and reduce stocks of crude and products to a point where the market will be favourably affected.

The present, therefore, is overcast; but the future will be largely of our own making. Rumania will be assisted by the fact that the Petroleum Industry as a whole has been one of the first to resolutely tackle the problem of over-production, and we have before us the example of what is being done elsewhere. But the idea that Rumania can be carried back to prosperity on the shoulders of other producing countries is misguided optimism. It is very striking how small is the quantity of cheap products that will unfavourably affect world prices.

The technical personnel of the industry is responsible for bringing on the crisis, through the introduction of rapid development and higher efficiency in production and refining: it is not, however, in the same position to ameliorate the situation. The companies in Rumania are working largely with foreign capital, and important decisions rest ultimately with executives, who unfortunately do not attend our meetings and may not read our technical journals.

However, we technologists can do something. At the present moment the most important thing is to use our best endeavours to make a success of some scheme of restriction of production. Because of the migratory character of oil, producers cannot slow down their efforts except by agreement. No restriction which involves obvious injustice will last; therefore we must try and smooth out the inequalities, and give the greatest assurance of fairness to all parties.

But the restriction of supply is, at best, an emergency method to tide the industry over its immediate difficulties. As soon as the present crisis is alleviated by this means, adjustments of a more fundamental nature will have to be undertaken. Such are the restriction of competitive off-set drilling, the abridgment of plant extensions and the modification of production methods to prevent waste and further reduce costs. A co-operative arrangement which merely limits total production is not sufficient, because so many wells may have to be drilled to protect boundaries that each well will eventually be pro-rated to an unremunerative amount of production. Further, drilling and production expenses are relatively high in fields drilled under competitive methods. An alternative is the unit operation of a geological structure.

This implies the consolidation of all properties within a specified area into a single unit which will be operated by one organisation, and the sharing of production, and likewise total expenses, by all the lease-holders.

If the legal complications permit, we must look forward to undertaking such schemes in the new areas which will be opened up in Rumania, and assist in overcoming the local difficulties in so far as they are psychological. Other countries are now doing it; and, unless Rumania produces as efficiently as the best, it will have its foreign markets taken from it, and the industry will be in a perpetual state of crisis.

It is a truism that no single section of an industry can prosper if that industry as a whole does not prosper. It may be that, in the near future, the statistical position of the Oil Industry will begin to affect the price structure favourably, and a return to comparative prosperity will appear imminent. This may still come about even with Russia pouring its oil products unrestrainedly on to the world market; but it can hardly happen if—to Russia—is added Rumania. Therefore I conclude this toast with the hope that the directors of our local industry may succeed in bringing it into line with the policy of the rest of the world, and give us Technologists a chance of justifying the existence of our respective companies by making successes of them.

I ask you now to join me in drinking to the toast of the "Rumanian Petroleum Industry"; and I have much pleasure in coupling with this toast the name of Mr. Otto Stern.

The toast of the "Rumanian Petroleum Industry" was then honoured.

Mr. Otto Stern, in responding to the toast of the "Rumanian Petroleum Industry," said:—

There is no doubt that the oil industry in general and not least the Rumanian oil industry is at the present moment at a critical stage in its history. I prefer to think of it as a "critical stage" rather than as a "crisis," as I think that more accurately describes the situation, but I cannot agree that the responsibility for this situation rests entirely with you.

I think you will agree with me that success in the oil industry is usually the result of a combination of luck and scientific labour. In the early days of the industry the factor of luck was very much more important than that of science. With the development of the industry and as a result of the activities and researches of its technologists we have to-day reached the stage where we might almost say that science has acquired a controlling interest in the industry, luck having retired to the comfortable position of a sleeping partner.

Progress on the scientific and technical side of the oil industry, especially during recent years, has been so great and so rapid that we are now faced with possibilities of production far in excess of the present needs of petroleum products. That is all to your credit, and no one can feel anything but admiration for the remarkable progress made by petroleum technologists and for the invaluable services rendered by them in the development of our industry in all parts of the world.

Your efforts have been unceasing in the search for new and better methods of exploitation and treatment, with the result that we are able to-day to drill to depths formerly thought to be impossible. We are able to produce our crude oil much more cheaply than before, and we are able in our refineries to treat the crude oil with much greater economy and to obtain from it a much greater proportion of its inherent value.

And yet you probably feel that all this progress has gone for nothing—or at any rate appears to have gone for nothing—because the industry seems to be much less promising than it was in the good old days when the drilling of a well was the work of a lifetime, when the best refiner was the one who could squeeze the largest amount into his kerosine fraction, and when benzine was an embarrassing by-product, which to a large extent had to be burned in the refineries in order to get rid of it.

What, Gentlemen, is the real reason for the present depression in our industry ?

To a large extent this is due to the effects of the general crisis through which the whole world is passing at the present moment and which has its repercussion on all industries, on the marketing of all finished products and on all raw materials. It would take me too far if I were to try to enter into the causes of this so-called world crisis, and I really think that it is unnecessary here to dwell upon it, as industrialists and economists in all countries—people who are much more fit to discuss such a question than I am—are writing and talking at great length about its origin and about the possibilities of providing means for its solution.

This world crisis has indiscriminately affected the economic life of all countries and of all industries and not least, that of the oil industry.

As a direct effect of this world crisis, we have now for the first time in many years the position that the consumption of petroleum products is not increasing, or not increasing to the extent that could have been anticipated, and even in some countries has of late decreased, whereas up to the middle of last year, the consumption of our products more or less all over the world has shown a steady increase. In this respect we have been more

fortunate than a good many other industries which for some years have had to face the problem of a decreasing or decreased consumption. So far as our industry is concerned, I believe that we are entitled to consider the present depression as a temporary situation, as everyone who is in touch with the distribution of petroleum products is fully convinced that, as soon as the general conditions begin to take a turn for the better, the demand for petroleum products is bound to continue its rising tendency. Naturally no one can say whether, in the near future, the upward curve is likely to be as steep as it has been in past years, but there can be little doubt that it will at any rate be upward.

But, apart from this, and even before we had to face this interruption in the increase of consumption, it had become apparent that, as the result of the increasing application of scientific and improved methods of production, we were bound to reach a stage when production would be far ahead of consumption, and beyond doubt this factor is another and more embarrassing cause of what I have called the present critical stage through which we are passing.

It is by no means the case that this state of over production has come as a surprise or has only been seen when it was already too late to avoid all the disadvantages which arise from it. On the contrary, the more far-seeing among the leaders of the petroleum industry have seen this possibility from afar. It is now some years since they not only drew attention to the possible difficulties arising from this, but since they also started to consider and to advise what could be done to avoid the tremendous consequences which would be involved if production were allowed to run far ahead of consumption. Ever since then they have used their endeavours to inculcate the idea of co-operation to the largest possible extent—co-operation not only in the matter of production and treatment of crude oil but also as regards the transportation and the distribution of products amongst all those interested in our industry and in all countries throughout the world.

It would take too long, Gentlemen, if I were to attempt to give you an account of all that has already been achieved in this direction and to indicate to you what still remains to be done to bring this work to completion. I will only say that oil producers in the United States whose production, as you know, represents about 70 per cent. of the total world production have actually cut their production to such an extent that, at the present moment, they are producing 18 per cent. below the total production of the United States during 1929.

As Mr. Penny has said, practically all other countries have followed this example, with the result that the total production of the world, in 1930, was about 3 per cent. below that of 1929, or, if we

exclude Russia and Rumania, the production of all the other oil-producing countries in 1930 was 5½ per cent. below their production in 1929. Here too in Rumania during 1930 some trials, if I may so describe them, were made in the same direction, trials which, however, did not prove themselves very successful and have of late been abandoned, as you know.

But, Gentlemen, you may ask why, in spite of the enormous sacrifices which producers have made by voluntarily keeping their production far below their potentialities, the present grave price situation on the oil market has come about. In my opinion, this is mainly due to the fact that it is often extremely difficult to get everyone to adopt those measures that are recognised to be necessary and useful, unless and until this necessity has been painfully emphasised by experiencing the full strain of the situation. It seems to me that the measures which have been taken were in many instances really put into effect too late, not too late to bring the industry out of its difficulties if the effort is continued, but at any rate and in many instances so late that the industry has had to suffer for not having taken the necessary precautionary measures to bring production into line with consumption in time and in a sufficiently drastic manner.

I believe that everyone who has watched recent developments, and who is conscious of the present situation, will harbour no doubt that the difficulties which still exist can be remedied by a whole-hearted co-operation, and that only with such continued co-operation will our industry have the possibility of going on in prosperity.

The times are past when the individual who looks only to his own interests and entirely forgets his neighbour can hope in the long run to prosper. It is certainly true that the enterprise with the most efficient organisation on its technical, commercial and financial sides is able more easily to withstand such a critical time as the present, but real prosperity of the industry as a whole can in these days only be based on co-operation.

Co-operation, however, is only possible if the general spirit exists that everyone should take on his shoulders his share of whatever sacrifices may be necessary—sacrifices which should be distributed on a just and proportionate basis over all those concerned. Co-operation, however, is impossible in an atmosphere of short-sighted and self-seeking desire to snatch a momentary advantage instead of making a long-sighted policy which should turn out just as much to the real advantage of the large as of the small enterprise.

However, the darkest hour is always that just before the dawn, and in view of the fact that in general the efforts to solve the industry's difficulties have recently become much more serious and more wide spread than at any previous stage and, as these efforts

are extending continuously, we may hope that our industry has at last come to the moment when we need not long await the appearance of the dawn of a brighter and better era.

That this may be the case not only for the oil industry as a whole but in particular for the Rumanian oil industry, and it is to be hoped in the interests of the industry, as well as all those whose welfare is closely connected with the prosperity of our industry, be they technologists, administrative employees or workmen.

"Our Guests."

Mr. J. Bolton, in proposing the toast of "Our Guests," said :—

In the name of the Rumanian Branch of the Institution of Petroleum Technologists, I extend a hearty welcome to all those who have done us the honour to take part in this celebration. Your presence among the members of the Institution, where all the professional men in petroleum matters gather and where everybody contributes with his knowledge and experience to the success of the Petroleum Industry, affords us great satisfaction.

After a special work of welcome in Rumanian to Mr. Brezeanu, the Mayor of Ploesti, Mr. Bolton continued :

Among our guests I am glad to see the happy face of Mr. J. Duqué, General Manager of Concordia. We have also Mr. Arthur Ashworth, who presided at our first annual dinner in 1927, and whom we are very happy to see amongst us this evening. We have also the pleasure of welcoming Mr. O. Stern, the General Manager of "Astra Romana," and we do not doubt that Mr. Stern will encourage us also in the future in the work and the aims of this institution. We are also glad to greet the Rev. A. Hawkins Jones, the new Chaplain in Ploesti, whom we wish a happy stay among the local congregation. I ask all members to raise their glasses to the health of our Guests.

Mr. Brezeanu, Mayor of Ploesti, speaking in Rumanian, eulogised the oil industry as a whole and the representatives of foreign companies in Rumania, without whom, he said, the industry would not be in its present efficient position. He added that the Rumanian people appreciated the skilled knowledge brought by foreign engineers, and that their activities were all for the good of the country. He had made many friends among them, and ended by hoping that they would always remain in Ploesti.

Mr. J. Duqué, also speaking in Rumanian, expressed similar sentiments. He was probably the oldest oil man present, having worked in Rumania for twenty-five years, and he was able to appreciate the wonderful changes which had taken place. He did not agree, however, with Mr. Penny that over-production was

the cause of our present trouble. The production of 1930, in comparison with that for 1929, only showed an increase of 5 per cent. An increase of 5 per cent. could not make a crisis such as we were now going through. Perhaps under-consumption had something to do with it. Here he appealed to Mr. Brezeanu, as a Deputy, to endeavour to have the State taxes lightened. At present, for example, a certain product was worth 2 lei a kilogramme, and taxes in all amounted to 6 lei, making a cost price of 8 lei. It should be reversed, the product should have a value of 6 lei and taxes should amount to 2 lei.

"The Rumanian Branch of the Institution of Petroleum Technologists."

Mr. Hipp, in proposing the toast of the Rumanian Branch of the Institution of Petroleum Technologists, said :—

It gives me pleasure to have an opportunity of adding my tribute of appreciation to the gentlemen who make it possible for us to hear interesting lectures and discuss together the burning questions of the oil industry.

I certainly think these gatherings of the oil clan are of mutual benefit to all who attend them. If the lecture on a particular night does not come within the province of certain men's activities, they are at least able to meet co-workers and exchange views. Whilst we appreciate the benefit which these meetings are to us all, let us remember the gentleman who, by his untiring efforts, in spite of difficulties, keeps the ball rolling, and show our gratitude by giving Captain Treacy our whole-hearted co-operation during the coming year.

The Institution of Petroleum Technologists should be more than a mere debating society. It should stand for everything which will ultimately bring about the most efficient and economic conditions, thus working for the good of the industry in general. Gentlemen, let us drink to the prosperity of the Rumanian branch of the Institution of Petroleum Technologists, coupled with the name of Captain Treacy.

Mr. J. Chaillet, in replying, mentioned that he had received a note of apology from Mr. Manoelescu, the Minister of Industry and Commerce, regretting his inability to be present at the dinner.

The Institution of Petroleum Technologists had its home seat in England, and the foreign members had been struck by the fact that in past years it had seemed as if the activity of the parent Institution in England had been devoted too much to technological questions and problems. Refinery and geological questions were important, but he was a field man, and he had

his own problems. He had no animosity against geologists, he had an admiration for their qualities and their results. The geologist told the field man where the oil was to be found, and he had to bring it to the surface. Field men had realised the necessity of bringing science to their aid, and that was why they now honoured geologists more than they did in previous years.

In the meantime there was a link between the field man and the refinery, and that was the pipe-line. He also made an appeal that in the future more of our refinery friends should be brought into our discussion, so that we could feel there was collaboration between refinery and field men in discussing and deciding their various problems. Thus would the various branches of the Industry be brought together.

A point in Mr. Penny's speech which made an impression upon him was that relating to unit operation. We should endeavour to realise that spirit. Unit operation meant not only the collaboration between two or three or four companies, but it meant fair play. Such unit operation could not be entered into here until the existing feeling of "you must not enter into my well," etc., had been broken down. The local meetings of the Institution of Petroleum Technologists should help to break down this bad feeling, where all meet as friends and discuss quite frankly their various problems.

This unit operation would be very beneficial. When one considered that all the small independent operators should also have the possibility of a proper existence, then the time would not be so far off when we should be forced into unit operation in various places; and he hoped everyone present would take this as his (Mr. Chaillet's) personal conviction that not only the economic question but also the development of research would benefit by the application of unit operation. The Rumanian Branch was grateful for the words of optimism expressed by Mr. Stern. This kind of optimism would help to carry us over the depression.

Mr. T. P. Perrott then proposed a toast to the Chairman, Mr. J. E. Chaillet, which was accorded musical honours.

The Chemical Aspect of Drilling Muds.*

By Alexander Duckham, F.C.S. (Vice-President).

I apologise for presenting a paper on a subject about which I know so little and of which I certainly make no claim to be a teacher. It is rather my desire for knowledge and my hope to create interest in this little understood matter which urges me to ventilate it.

I ask you to bear in mind that this paper was drafted some six months ago and that in the interim several articles have appeared in the American press.

Realising my ignorance, I sought knowledge among the technical staffs of oil fields which I visited, and I was struck by the general lack of such knowledge, not only with regard to ordinary drilling muds, but also, as might be expected, in the case of the complications which ensue when a mud is, as I would term it, "doctored," in order to change its specific gravity, viscosity or colloidity and to re-condition it when it has become useless owing to changes brought about by external influences, *e.g.*, admixture with fine sand, impregnation with gas, coagulation due to access of salt water, etc. Generally, I found that, with the exception of one or two men of scientific bent, knowledge was very rudimentary, and this is as might have been expected, because the field men had not had the scientific training essential to the study of the question, nor had they behind them adequate laboratory assistance, nor had they available any published information—my own search revealed how barren was that source; indeed, turning up the Journals of the Institution of Petroleum Technologists covering the past few years, not only could I not find mention of mud, but there was absolutely no reference to the use of "doctoring." The most useful information available seems to be that afforded by the commercial pamphlets of American firms who are marketing proprietary specialities for purposes of "doctoring." With their kind consent, I have drawn on them for curves and data. I refer to the Baroid Sales Company of California and to the California Talc Company, the latter being the makers of Aquagel.

As to history, the fact that such standard works as those of D. T. Day and A. Beeby Thompson make no mention of "doctoring," shows the modernity of its application in petroleum technology. I have heard that mud fluids were used in France some sixty

* Paper received February 3rd, 1931.

years ago when drilling for water, but there seems to be no authentic information as to the recognition of mud as a standard auxiliary in the drilling of oil wells until 1914, when Pollard mentioned the use of mud fluid in percussion drilling.

I should imagine that with the first rotary well, having to use some vehicle for bringing the cuttings to the surface, water was made use of, and it was found that in some cases the water absorbed solid material from the cuttings and so transformed itself into a mud which was at once recognised as a more valuable vehicle for the purpose, on account of its "body," than pure water.

However that may be, the fact is that to-day the vast majority of the wells of the world are drilled by the rotary system in conjunction with a mud flush.

My object in including the word "chemist" in the title of this paper is to attract his attention to the subject, because he is, in my opinion, *sine qua non* to the proper use of this adjunct to present day drilling. Indeed, I know of no other opening, nor do I think there has ever been one, on the actual oilfield, which has offered such scope for chemical assistance, and my experience when investigating mud on the fields shows clearly how welcome to the management would be the assistance of a chemical expert to indicate not only how they should begin their handling of mud, but also how they could remedy their troubles when, as is an everyday occurrence, something goes wrong with it.

Purposes.

Let me set out some of the many purposes that mud should serve :—

1. To act as a carrier of the cuttings from the bit to the surface.
2. To keep the cuttings in suspension and so reduce to a minimum any settlement when circulation ceases, either voluntarily or involuntarily.
3. To prevent its own undue escape or leakage into the formation through which the drill passes and thus not only prevent undue waste of an expensive article, but also prevent that loss of circulation which occurs if the formation absorbs mud to the capacity of the pumps.
4. To act as a lubricant not only between the formation and the rotating bit, but also to the drill-pipe.
5. To prevent the seizure or "freezing" of drill-pipe, casing, etc.
6. To minimise the abrasive action of sand and rock particles in the pumps, etc., not only by acting as a lubricant, but also by obviating or reducing the entry of sand into the well.
7. By its cushioning and floating effect, to facilitate the accurate and smooth handling of casing under perfect control.

8. Nowadays, perhaps most important of all, by the pressure the mud exerts, to keep gas absolutely back in the formation so that operations shall not be jeopardised by blow-outs, or the mud itself be rendered useless by that impregnation with gas which is generally referred to as "gas cutting." (This matter is so vital and, I venture to think, so much misunderstood, that I have, at the end of this list of purposes, referred to it again at some length.)

9. To perform this same function of imprisoning in the formation in the case of water and oil.

10. To plaster the walls of the hole and of cavities or exhausted sands, so as to prevent caving, collapse or sloughing.

11. As asserted by some drillers, to reduce the risk of getting a crooked hole, and this on the ground that the bit is kept clear of cuttings, *i.e.*, of "balling up." But may it not on occasion be rather responsible for a crooked hole if the strata be steep or if boulders be encountered, as one would expect that its very lubricating properties would tend to make the bit slide off at an angle from the vertical?

12. To minimise the danger of the cement in deep wells setting before it gets beyond the shoe and so into the cavity to be cemented; this being prevented by its weight increasing the rate of the passage of the cement.

13. To facilitate the reliable taking of geological cores in high pressure formations.

14. Last, and far from least, to protect the driller and crew from the danger of blow-outs and, perhaps, consequent fire. It is strange that nowhere does there appear to be any reference to this important function. Such security enables a man, however good he may be, to concentrate better on his work, as he has not his attention diverted by thoughts of the safeguarding of himself and the crew, and, incidentally, of the valuable plant under his charge, and so he stands a better chance of getting everything fitted up in peace and quietness before he brings the well into production. Hurry and anxiety generally mean faulty work.

Blow-outs

I will now enlarge, as mentioned in clause 8, on a factor which I believe has hitherto been overlooked as a possible cause of those apparently inexplicable blow-outs which frequently occur when one knows positively that the maximum formation pressure is much less than the pressure which is being artificially imposed upon it by the weight of the column of mud.

May it not be that the trouble is started by hydrocarbons, which are gases at ordinary pressures, but are true liquids, or are dissolved

in the hydrocarbons of higher boiling-point, at the pressures at the bottom of the well, and which assume the form of gases when, in their ascent of the well, they arrive at that particular level at which the reduced pressure allows them to boil ?

The following list gives an idea of the liquefying pressures of certain hydrocarbons found in petroleum gas and the depths at which, under columns of mud 72 lbs. and 108 lbs. per cubic foot respectively, they would be liquid.

	Pressure to liquefy at 15·5° C., lb. sq. in.	Mud depth (72 lbs.) feet.	Mud depth (108 lbs.) feet.
Methane	?	?	?
Ethylene	above 1000	above 2000	above 1333
Ethane	475	950	633
Acetylene	1000 (approx.)	2000 (approx.)	1333 (approx.)
Propylene	100	200	133
Propane	105	210	140
Cyclopropane	80	160	107
Allylene	50	100	67
Butylene	40	80	53
Butane	35	70	45

No allowance has been made for earth temperatures and this because their incorporation would mean considerable calculation, and, indeed, there seems to be no data available as to what are the actual temperatures of the cuttings as cooled by the descending stream of fresh mud.

As to solubility of the gases in oil, Osgood published matter which leads to the conclusion that, at a pressure of 600 lbs., twenty volumes of natural gas dissolve in one volume of Oklahoma crude oil. The composition of the gas was :—

Methane	52·0 per cent.
Ethane	39·0 „ „
Carbon dioxide	1·2 „ „
Oxygen	0·4 „ „
Undetermined	7·4 „ „

Compressibility must just be illustrated, and the following figures are based on Boyle's law, but would in practice be exceeded to an extent depending on the composition of the gas.

Pressure, lb. sq. in.	Increase in volume on release of pressure.
100	7 times.
300	21 „
600	41 „
1000	68 „
1500	101 „
2000	134 „
3000	201 „

My idea that the actual core of oil sand contains in some cases enough liquefied and dissolved gases to start the gas-cutting of the

mud calls for some estimate of the capacity of the cuttings to provide an adequate volume of such gases. At the same time let me ask whether there is any other theory extant for explaining how it is that when the gas exerts only a pressure of, say, 1,000 lbs., it is able to force its way into the well against a positive pressure of mud, say, of 2,000 lbs. and over, as in practice it appears to do.

Suppose a well is 1,950 ft. deep and the bit cuts through 50 ft. of sand, making a total depth of 2,000 ft., and that the mud is 110 lbs. to the cubic foot and so exerts a pressure of 1,500 lbs. per square inch on the sand stratum. At such pressure the gases will all be liquid or dissolved in the oil.

Suppose that the interstices occupied by oil are a quarter of the volume of the sand, and that the liquefied and dissolved gases are in their turn equal to a quarter of the volume of the oil, *i.e.*, equal to one-sixteenth of the sand cylinder or approximately 3 ft. out of the total 50 ft.

The various components would commence to boil at different depths as the cuttings rose, and, at the surface at normal temperature and pressure the resultant gases would have a volume equal to a cylinder 2,850 ft. high, or nearly half as much again as the borehole and of the same diameter. Indeed, considerably more if allowance be made for the volume of the drill-pipe and its contents.

Once the vaporising starts at certain points, comparatively high in the well, the consequent lightening of the mud column would permit expansion at even greater depths until at last the oil, owing to reduction of pressure, begins to vaporise in the formation itself at the very bottom of the hole, and to pour, with little or no restriction, into the well.

Would control on the discharge of the mud from the well remedy this trouble and be practicable? The descending column will always exert its normal pressure due to its weight plus the pump pressure, but the ascending column, on the release of gas, will become lighter and lighter and discharge with increasing force and speed, deriving the energy therefor from the expansion of the gas. The decrease in pressure at the bottom of the well may be only slightly reflected in a reduction in pressure at the pump owing to the viscosity of the descending mud. If a control valve were used to restrict discharge, maintain a steady flow of mud and particularly to check any tendency for the pressure to drop, should not gas cutting from that cause be obviated or, at any rate, be much reduced? Drillers are peculiarly sensitive in "feeling" for changes in conditions and, no doubt, would soon accustom themselves to "spot" gas in the mud column by momentarily closing the discharge valve and noting whether the pressure rose rapidly (*i.e.*, no gas) or

slowly (*i.e.*, gas present and being compressed) and adjust the valve so as to limit the vaporisation of the gases to a minimum.

Before leaving this subject it may be well to indicate a few well temperatures. At Guapo (Trinidad) on well No. 3 the readings we took were :—

300 ft.	92° F.
600 ft.	92 °
900 ft.	94°
1200 ft.	96°
1500 ft.	100°
2100 ft.	104°

The U.S. Geological Survey published some figures for greater depths and the following are the average for three wells :—

3000 ft.	92° F.
4000 ft.	108°
5000 ft.	126°
6000 ft.	147°
7000 ft.	165°

Generally it has been accepted that temperatures increase 1° F. for each 55 to 60 feet increase in depth.

Composition, etc.

Returning to mud—its composition and qualities can perhaps best be dealt with under two headings :—

(a) Ordinary mud.

(b) " Doctored " mud.

By " ordinary " is meant the mud prepared from local, or perhaps imported, clays, which, when mixed with water, form the basic drilling fluid which may be " doctored " by the addition of some comparatively expensive ingredient when the condition of the well justifies.

Ordinary mud, if suitable clay be available locally, is generally prepared hydraulically by playing a high pressure jet of water on to the clay. If such clay be in a hillside, work is rendered easy as it can be arranged that the mud runs by gravity through a screen to remove lumps and then into a pit, from which it is pumped again to the working surface, and so round and round, becoming heavier and heavier until the weight tester shows that it has reached the desired standard ; it is then pumped into the storage tank or direct to the well-side pit.

If the clay has been dug, it is then generally "pugged" up with water by manual or by mechanical means, and sometimes this is assisted by the introduction of steam and the use of the water jet.

The organisation of a mud-mixing outfit depends on the lay-out of the wells and the average amount and the peak amount of mud required per day, etc. It is quite a simple matter and needs no further mention here.

The weight tester may consist of a can of known capacity which is filled with mud to the brim, and the weight is taken on a spring balance, the dial of which is so marked that it reads the weight per gallon, or per cubic foot, and so does away with the need for calculation. Lately a useful refinement has been introduced in the form of a conical vessel through which the mud flows and its weight is automatically and continuously registered on a dial. Some fields favour the gallon and others the cubic foot as the volumetric unit—in this paper a cubic foot is used.

Clays naturally vary within wide limits in the fineness of particles, in specific gravity and in colloidity. On some fields beautifully smooth and heavy, but not too viscous, mud is quickly and cheaply prepared and needs no "doctoring" for ordinary straight drilling where pressures are not inordinately high; on other fields coarseness, grit and lack of colloidity make the mud poor stuff for use even in the easiest conditions and "doctoring" may be necessary from the start. In some cases poor mud can be used to start a well which it is known will, in due course, penetrate formations, supplying clay to improve the quality of the fluid. In some fields, so much does the mud increase in volume and viscosity from clays in the formation that not only has much to be discarded, but water has to be added to reduce the viscosity. It is said, I think with justification, that generally the deeper formations are the less likely they are to provide good mud-making clays.

It is the problems of "doctoring" which have hitherto been so little understood, which are so very interesting, and which, from the technical and financial viewpoint, call for thorough investigation and yet have been so little studied. And it is this side of the question, embracing the compounding, the using, and the reconditioning of "doctored" muds, that this paper ventures crudely to survey.

The three main properties of the mud, which it is desired to control by "doctoring," are :—

1. Weight or specific gravity.
2. Body or viscosity.
3. Colloidity.

The weight of ordinary mud varies with the clay used and so with the locality. In Trinidad, the Forest clays yield ordinary mud up to 85 to 87 lbs. per cu. ft., but this generally is too viscous for routine use and 72 to 75 lbs. mud is a happy mean.

The viscosity also varies with the locality, and, unfortunately, I have no comparable figures. The limiting factor in practice is never weight but rather the viscosity, and the aim is to get the maximum weight with the minimum viscosity and with adequate colloidity.

Fig. 1.

On account of the presence of largish particles of solid matter and of the colloidity which renders the mud gelatinous when at rest, such viscometers as the Redwood, the Engler and the Saybolt are useless for mud testing purposes. In Trinidad, the local branch of the Institution of Petroleum Technologists have standardised a special viscometer.

In the United States the "Stormer" viscometer is used. It takes the form shown in Fig. 1.

This instrument measures the speed attained by a cylinder which, by means of a weight, acting through a spindle, a gear and a pinion, is caused to rotate in a test cup surrounded by a bath of water or oil to maintain the desired temperature. A revolution counter is connected to the spindle which supports the cylinder, and the number of times required for the latter to make a specified number of revolutions in distilled water and in the liquid under examination forms the basis of comparison.

The test cup is held concentric with the cylinder by three arms projecting inward from the wall of the water bath, while it is prevented from rotating by a stop-plate engaging one of these arms.

The water or oil bath is kept in position by a recess in its support. By loosening the clamping screw in this support it may be raised or lowered, permitting the ready introduction of the cylinder into the liquid in the test cup, the height of the latter being determined by an adjustable collar on the pillar. As generally used, the bottom of the water jacket during the test is placed about 6½ inches above the base to permit heating by a gas burner or alcohol lamp.

But surely any viscometer must be unreliable when used on the rig or, indeed, in the laboratory, if the mud contains gas, or if it be so colloidal that a certain critical amount of agitation is required before it assumes its maximum fluidity. As an instance of gas effect, I came across a case where the Trinidad viscometer was filled to the brim and the standard quantity was run off for the test, but the viscometer remained full to the brim on account of the gas that had been given off in the meantime.

Specific gravities and viscosities are simple and more or less positive factors which are easily comprehended and controlled, but this is not the case with colloidity, which is elusive and complex in the permutations and combinations which it affects even in drilling muds, and I approach it with diffidence and in the hope that I may attract the attention of the chemist to the field which it affords for his investigation in this branch of industry.

The word colloid comes from the Greek "kolla" meaning glue, but glue in its everyday application is not a happy simile for colloidal properties as viewed from the drilling standpoint. Rather then can a colloid be regarded as a substance in such a state of dispersion in another medium that its condition of intimacy of division is intermediate between that of an emulsion and of a solution. At least that is my elementary understanding of the state of affairs.

There are no gaps or fixed points of demarcation between the three states, but each has its definite characteristics. The fineness of division may be roughly denoted by saying that in an emulsion the particles are distinctly visible under the ordinary microscope,

that in colloids the ultra-microscope must be used, and that in solutions they are invisible whatever power of magnification be used.

In all three categories dispersion is maintained by the interplay of molecular forces, and it is only in the case of comparatively coarse emulsions that gravity is sufficiently preponderate to cause separation and settlement. In the case of emulsions and colloidal solutions a rapid movement of the particles, due to molecular impacts, is observable under the microscope.

What is of importance to us, in the matter of mud, is that even such coarse mixtures or emulsions (*e.g.*, suspensions of clay, graphite, etc., in water) can be stabilised by the introduction of colloids. Here I visualise the particles of clay, graphite, etc., as receiving a surface layer or coating of a true colloid (for example, of soap, tannic acid, gelatin) which, being possessed of strong dispersive properties peculiar to the colloidal state, not only retards coalescence but also keeps them in motion.

Many substances which are commonly regarded as true solutions are in fact colloidal, for example, gelatin in water, soap in water, aluminium oleate in oil, etc. Emulsions are seldom transparent, but colloidal and true solutions are transparent because the particles, in relation to the wave lengths of light, are too small to disperse light.

The degree of stability or resistance to separation in emulsions is generally in inverse ratio to the size of the particles—the finer the more stable. Naturally a colloidal solution is more difficult to separate than is an emulsion, but both, given a filter of correct type, can be separated by filtration. A solution cannot be so separated.

When an emulsion is possessed or a certain amount of colloidity it becomes immobile and jellylike when at rest, but becomes fluid again when agitated. Increase the colloidity and it remains a solid jelly such as will not yield to agitation. Reduce the colloidity below the "certain" amount and it will not jelly even on long resting. The first of these conditions is that generally required in drilling muds.

Colloidal fluids give body or high viscosity curve for a low content of solid matter as compared with other fluids; thus, colloids do not give weight but do give suspension of solid particles and do secure a minimum penetration by the mud into porous formations in a well, and so reduce the loss of mud. But as colloids increase in body or viscosity their function in this direction has to be strictly limited by the practical considerations, such as pump suction, free flow in pits and trenches, settlement of cuttings, etc., and in this connection it must be borne in mind that the adding

of the weighting reagent also increases the viscosity. In some cases the limit of viscosity is reached when the desired specific gravity has been attained, but before the colloidity is adequate, and then the question of adjudicating between weight, viscosity and colloidity, jointly and severally, is one for reference to the laboratory.

Colloids are sensitive to several disturbing reactions, for example coagulation by heat, by chemical and electrical agencies, and necessarily the diagnosis of the causes of such troubles is quite the capacity of any ordinary field staff. Two examples—salt water will destroy the colloidal coating and permit separation; a mud charged with negative electricity may be separated by the admixture of particles charged positively.

Now, as to testing or estimating colloidity—I have come acros s no standard method. As it is desirable that it should serve for field use it must not be intricate. It would appear that it must comprise some ratio between viscosity and the rate of settling of the mud. Here is another useful problem for the laboratory.

The first interesting work in connection with mud is that which is almost exclusively a duty for the laboratory, and that is the diagnosing of the short-comings of the ordinary mud available and prescribing the methods to be adopted for its improvement, in order to impart those properties which it lacks for the particular conditions under which it has to be used. That is to say, to give it the optimum balanced combination of weight, viscosity and colloidity. For such prescription to be ordered by any than an expert chemist appears to be asking for trouble and for waste of money.

There is no doubt that the range of materials and methods to be used for "doctoring" will be expanded in the future when the subject has had closer study, but at present the list seems to be confined to a few substances, as follows :—

Barytes is almost exclusively used as the reagent for increasing weight, although one hears at times of hæmatite being employed, and I find mention of it as early as 1925, that is before I can find any reference to barytes. Compared with barytes it has obvious drawbacks, *e.g.*, cost, abrasiveness and depth of colour, although on the other hand it has a higher specific gravity. The purveyors of barytes, and so, indirectly, the users, are in a favourable position as they draw their supplies from an old-established manufacture which has for many years been perfected to meet the requirements of the manufacturers of paints, in which industry it is commonly used as a substitute for white lead.

The consumption has been of the order of 450,000 tons annually, but this is now greatly increased by the use on oil fields. Germany has produced about half of the supply, and the U.S.A. and then Great Britain come next as producers. It is regrettable that the German deposits yield a superior quality to those found in England.

Chemically pure barytes is normal sulphate of barium, $BaSO_4$, and in nature occurs as the mineral "heavy spar" in the form of a crystalline mass. Generally the colour is whitish, but it may be reddish in the presence of iron. There is also an opaque variety of which the specific gravity is somewhat less than that of the crystalline, the respective figures being 4·2 and 5·0. The mineral is remarkably pure in its natural state, in that it contains normally some 95 per cent. of barium sulphate.

The process of manufacture is simple, generally consisting as it does of grinding and levigation after the raw material has been picked over to remove obvious impurities. After crushing, the coarse powder is ground with water and then allowed to settle. The upper layer is removed for more thorough levigation. The paste is dried and then powdered in disintegrators. In some cases air flotation is substituted for levigation.

The use of barytes on an oil-field is very beneficial to the barytes manufacturer, as it gives him an outlet for lower grades which are not acceptable to the paint manufacturer.

For "doctoring" muds the degree of fineness and the absence of grit are of first importance, and whereas formerly oil fields bought barytes on a 200 mesh basis they can now rely on obtaining a 300 mesh at the same price; although a still finer mesh would be desirable, its use is not justified as a marked increase in price would be incurred. It has to be borne in mind that the larger particles are siliceous and, therefore, more difficult to grind and are undesirable as being abrasive.

The specific gravity should be about 4·2, but I have come across cases where deliveries sank as low as 3·56. Anything under 4·0 should be rejected. Alkalinity should be watched as any excess, *e.g.*, due to carbonates, might cause ropiness or coagulation. It seems desirable that a standard specification for oil field work should be prepared.

As clays generally have a specific gravity of about 2·3, equalling 144 lb. per cub. ft., as against barytes of about 4·2, or 262 lb. per cub. ft., its potentiality as a weighting material is apparent. As an example, a 75 lb. clay mud may have the same viscosity as a 130 lb. barytes and water mud.

The following table for specific gravity and weight equivalent and the interesting chart—Fig. 2—for calculating the quantity of barytes to be added to ordinary muds to obtain the desired weights, are to be taken from the Baroid Company's leaflet.

Table of Specific Gravity and Weight Equivalents.

Specific gravity.	Lb. per cu. ft.	Lb. per gallon.		Specific gravity.	Lb. per cu. ft.	Lb. per gallon.
1·00	62·3	8·33	..	1·50	93·6	12·52
1·05	65·5	8·75	..	1·55	96·6	12·93
1·10	68·6	9·18	..	1·60	99·7	13·34
1·15	71·8	9·60	..	1·65	102·9	13·76
1·20	74·9	10·00	..	1·70	106·0	14·18
1·25	78·0	10·43	..	1·75	109·2	14·59
1·30	81·2	10·84	..	1·80	112·3	15·01
1·35	84·3	11·26	..	1·85	115·4	15·42
1·40	87·4	11·68	..	1·90	118·5	15·84
1·45	90·5	12·10	..	1·95	121·6	16·26
				2·00	124·7	16·67

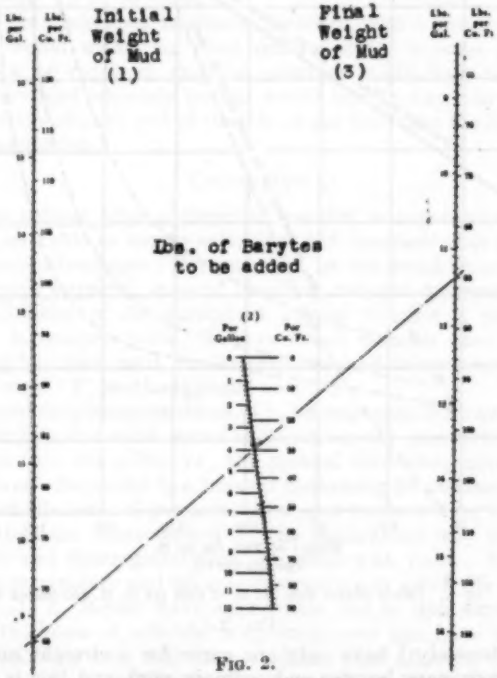
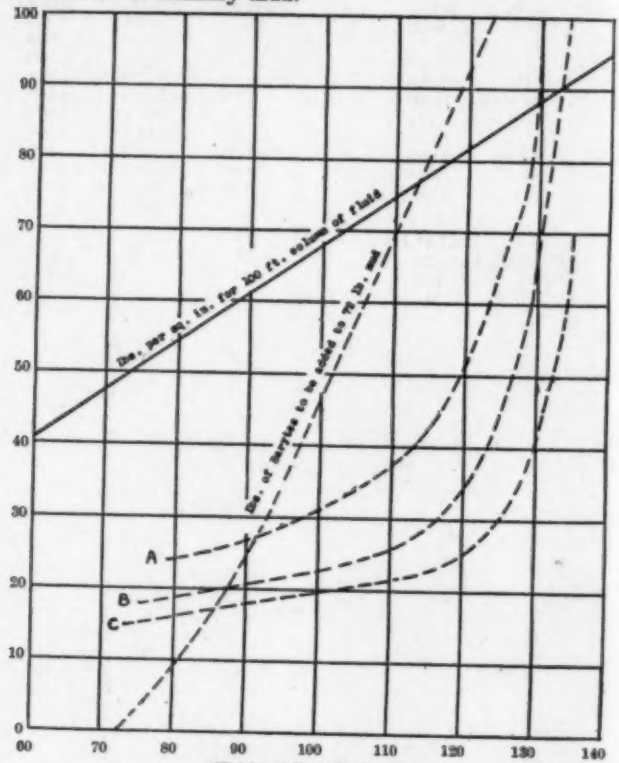


FIG. 2.

CHART FOR COMPUTING QUANTITY OF BARYTES TO BE ADDED TO INCREASE WEIGHT OF ROTARY DRILLING MUD.

On this chart the left hand line (No. 1) gives the weight of the ordinary mud before the powder is added. The right hand line (No. 3) gives the weight aimed at. A straight line connecting the

weight of the existing mud with the weight desired will, where it intersects line No. 2, give a reading of the number of pounds of barytes which must be added to obtain the desired result. For example, if you start with a 65 lb. per cub. ft. mud and you are aiming at an 85 lb. then 29·6 lb. of barytes must be added to each cub. ft. of ordinary mud.



Viscosity Curves.

A. 78.5 lb.
B. 75.0 ,,
C. 72.5 ,,
} Muds treated with 187 lb. of soda per cu. ft. and loaded with barytes.

FIG. 3.

Unfortunately I have only one curve for a straight mixture of a non-proprietary barytes and ordinary mud, and this is included as Fig. 3, which was kindly given to me in Trinidad by Mr. J. L. Harris. The curves A, B and C are complicated in that soda has been added.

In Trinidad the weights standardised for "doctored" muds vary with the different companies, but not materially. The means of the figures available go to show that ordinary drilling mud varied from 72 to 80 lb, and that when this was going to be used for the addition of barytes it was thinned down to 65 to 72 lb, and then brought up by the addition of barytes to a figure varying from 95 to 120 lb. In a case where soda was being added, they were using 130 lb mud of workable viscosity.

In practice, impregnation with gas or "gas cutting" has a marked effect on weight and on viscosity. I came across a case where the viscosity, owing to gassing, rose to 300 secs., whilst the weight varied from 80 to 85 lb. The driller then appreciably de-gassed by jetting the mud against a flat plate, and almost at once the viscosity went down to 32 secs., whilst the weight went up to 90 to 92 lb.

It has been said that in theory, mercury, with a specific gravity of 19·2, would make an ideal drilling fluid, because pumping would not be required, and the cuttings would float rapidly to the surface, and certainly no gas would find its way into the well. The question of costs and of the loss of the fluid into the formation is not mentioned.

Colloidity.

At the present time a chemical reaction is apparently seldom used on oil fields to secure colloidity, but one feels that it might have many advantages; for example, in the small quantities of the reagents required, ease of handling, reduced transport, etc.; the possibilities of its adaptation appear to offer a promising field for laboratory work. I have heard rumours that sodium aluminate has been used, the amount required being from 0·01 to 0·02 per cent. P. Scott suggested soap.

At present the physical method—*i.e.*, impregnation by or admixture of an infinitely fine solid, seems to be universal; and furthermore, it appears that one solid—*i.e.*, the mineral bentonite, monopolises the position. Bentonite is a mineral containing 60 per cent. silica, 18 per cent. alumina, 10 per cent water, and traces of lime, iron, etc.

Bentonites are characterised by the remarkable way in which they swell and disintegrate when saturated with water. They are said to have capillary and micaceous structure in which the crystals (to quote J. E. Meyer) have appreciable size in two dimensions, being of thickness of colloidal magnitude, and also have the property of splitting into still thinner plates, thus allowing water to penetrate the mass rapidly, forcing its way between the micaceous leaves of the crystals. Bentonites result from the weathering and disintegration of volcanic ashes. They are found chiefly in the

U.S.A. and Canada. Generally they are whitish in colour, and the specific gravity is about 2·5. They are chemically inert, but the above-mentioned remarkable property of taking up water extends even to the absorption of thirty or more times their own weight; hence the swelling and the assuming of the form of a gel, the particles being to some extent so fine that they come into the ultra-microscope category. Such gel, when mixed with ordinary mud, gives a coating to and vehicle for its solid particles and retards their movement in all directions. The amount to add to ordinary mud to secure the best results, and not to overdo it, is an important question, and in view of the great variations in the colloidal quality of clays, requires to be determined in the laboratory. H. F. Beardmore suggests an interesting guide when he advocates the addition of 0·02 per cent. of bentonite to the mud for every 1 per cent. of settling which would otherwise occur in 24 hours. The standardising of this settling test appears to be desirable.

To include carefully compiled data as to the effect of solid colloidal agents, I have to avail myself of the courtesy of the California Talc Company, as they seemingly are the only publishers of accurate work on this subject. Their commodity "Aquagel" is, I am told, a bentonite. I do not reproduce their interesting curves, as they are complicated by matters not of immediate interest to us, but I summarise certain information based on these curves. It should be noted that the viscosities are taken at 100° F. by Stormer viscometer and are expressed in centipoises.

Curve A gives a mixture of the solid colloidal reagent and water; 3·25 per cent. produced 5 centipoises and 4·25 per cent. 15 centipoises. This latter figure can be taken as a fair minimum for drilling purposes, but such mixture would be too low in specific gravity for use with high-pressure formations.

Curve B shows a mixture of 66 lb. ordinary mud (Wilmington) containing 10 per cent. of solids and having a viscosity of 2 centipoises. The addition of 2·5 per cent. of the reagent gives 7 centipoises, and 3·25 per cent. 15 centipoises.

Curve C shows the use of the reagent with an inert non-colloidal earth. Mud containing 14 per cent. of this earth gave 1·5 centipoises. The addition of 4 per cent. of reagent to that mud gave 5·5 centipoises, and 6 per cent. 15 centipoises.

Curve D is for Wilmington mud thickened by the addition of its own clay, no colloidal reagent being employed, and it shows that to reach 15 centipoises the amount of clay to be added is 27·5 per cent.

Curve E is for a mixture of an inferior Oklahoma mud and in this case about 45 per cent. of clay is required to reach the desired centipoises.

Alkalinity.

Except on the oil fields, I have not come across any mention of soda as a reagent in "doctoring" muds, yet it would appear to be of fairly general application. It serves to reduce viscosity without perceptibly reducing the weight, or, putting it another way, with its use the weight can be increased without reaching excessive

viscosity. A 130 to 140 lb. mud with soda can have the same viscosity as 110 lb. mud without soda. Presumably its action is due to its effect on colloidity. The difficulty of field men in connection with the chemistry of muds is instanced by the fact that on some fields the staff do not differentiate between soda crystals and soda ash, although the soda crystals consists of one molecule of sodium carbonate plus ten molecules of water, whereas soda ash is almost pure sodium carbonate, and, therefore, weight for weight, about three times as potent as is the crystal.

Soda ash is generally the cheaper on account of the lower transport cost, etc., per unit of alkalinity. The amounts of soda used are very small, being of the order of 0·2 per cent. of sodium carbonate. Working figures were noted at 0·2 lb. soda crystal per cu. ft. of mud, and in another case 2 oz. of soda ash had been used per cu. ft. of mud, but no data was available as to the weight of the mud. An excess of soda causes ropiness and separation. In view of the potency of small quantities of soda, great care must be taken when mixing it with the mud to see that it is equally distributed, as will be appreciated from the figure of 0·2 per cent. mentioned above.

In deciding the amount of soda to be added, the alkalinity of the ordinary mud should be determined, as should the alkalinity of the water. It is not always appreciated that the shales and clays are generally alkaline. McKenzie Taylor's work in this connection is interesting. Below is his table of replaceable sodium and calcium :—

Spec. No.	pH value.	Replaceable bases (milligram equivalents per 100 grams shale). Na.	Ca.
1	9·4	12·4	5·6
2	9·2	7·2	0·8
3	8·6	Insufficient for determination.	
4	8·6	5·7	4·0
5	9·0	7·7	4·2
6	8·4	Insufficient for determination.	
7	10·4	21·0	5·0
8	8·6	16·8	2·3
9	9·0	19·0	6·6
10	9·0	13·8	6·5
11	9·6	11·2	4·1
12	8·6	6·3	4·2
13	8·4	6·3	4·4
14	8·8	8·7	1·8
15	8·8	7·3	3·4
16	9·0	5·8	2·2
17	9·2	17·6	6·6
18	9·6	27·7	9·9
19	9·8	29·6	7·1

C. P. Parsons (*Oil Weekly*), in discussing colloids, says that theoretically clay particles reach maximum dispersion when the alkali reaches the pH value (hydrogen ion concentration) of 9 or

over, but goes on to say that, in practice, this does not always obtain, as (indeed, he is supported by field experience) a point is reached, on adding the alkali, when flocculation commences. This question of alkalinity calls for further laboratory investigation.

Salt Water.

As to the action of salt waters, there seems to be little definite information, although it is generally recognised that an excess of salines destroys the colloidal character of the mud, and in ordinary practice such "salted mud" is thrown away. In one instance a figure was given me by P. Scott, who mentioned that salinity up to 0·2 per cent. of sodium chloride was generally safe, and that in Trinidad the ingress of salt water is generally not dangerous because natural water pressures are low, although there are at times cases of salt water being driven into the well by high gas pressures and the mud being completely spoilt.

Handling.

The lay-out and procedure in mixing and handling mud is such an everyday matter that it needs no description here, except to call attention to the fact that efficient screening to remove cuttings is, strange to say, not nearly so universal as it should be, and many fields remain satisfied with the old, slow, inefficient process of settling, a method which consumes much time and necessitates undue capacity of settling pits. As one would expect, a certain amount of separation occurs in the pits and, sometimes, the top layer being the finest material, is separated off as being of superior quality and as much as 60 per cent. is thrown away. In any case, "doctored" muds must be expensive and so efficient handling is a real economy.

The crudest form of screening is to pass the mud through a small mesh galvanised wire, but the use of real mining screens of 24 to 34 mesh is fully justified and is rapidly coming into use, and, indeed, in the States during the last few months mechanically vibrated screens have been proving their worth. The use of screens, classifiers, and other ideas taken from ore mining practice will have a definite use in connection with "doctored" muds. Most fields, even if running only three or four rigs, are justified in installing a central mud mixing and tank storage outfit, not only in order to supply uniform mud to the wells, but also to take back mud for reconditioning. The amount of mud that is wasted—being left in pits or thrown away—is still colossal. Better still is the practice of certain fields in the States which, being reasonably close to one another, have united to run a co-operative mud farm.

To what extent screening will be effective and justifiable in removing sand has yet to be determined. Of late a great interest has been shown in the States and quite elaborate installations are under trial. As to degassing, it is fairly common practice to jet the mud at the well against a plate and thereby effect a worth-while improvement at little or no cost, as was evidenced in the case mentioned above in connection with weight-viscosity figures. These matters are of such first importance that they are dealt with more fully under "Reconditioning."

The addition of barytes is generally made through the jet and mixer in some such form as shown in Fig. 4.

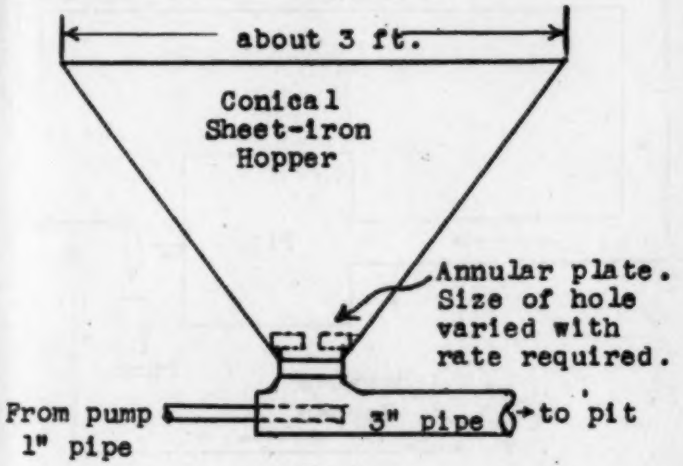


FIG. 4.

The ordinary mud is pumped through the jet, the barytes being put into the cone so it is drawn down by the fluid and taken with the mud stream into the suction pit. The lay-out of pit, trench and mixer is shown diagrammatically in Fig. 5.

How to calculate the amount of barytes to be added to the ordinary mud to give the required weight is best shown by a definite example. The well is 3,000 feet deep and drilled with a 10-in. bit. It has been decided that the ordinary 70 lb. shall be weighted to reach 100 lb. The ordinary mud in the hole will have a volume of a cylinder 10-in. in diameter and 3,000 ft. long, *i.e.*, 1.650 c. ft. Turning to that useful chart in Fig. 2 and running a line from 70 lb. (column 1) to 100 lb. (column 3) it will intersect

column 2 at a point indicating that 48 lb. of barytes must be added to every cubic foot of the ordinary mud, therefore, 1,650 by 48, or some 39½ short tons is the amount that has to be added.

If the rate of circulation be 40 c. ft. per minute, it means that the 1,650 c. ft. will make one complete circuit in 41 minutes, and it is of the greatest importance that the admixture shall be made very uniform throughout the whole stream of mud, therefore in this case it means that it must be added practically at the rate of some 1930 lb. per minute, or some multiple thereof.

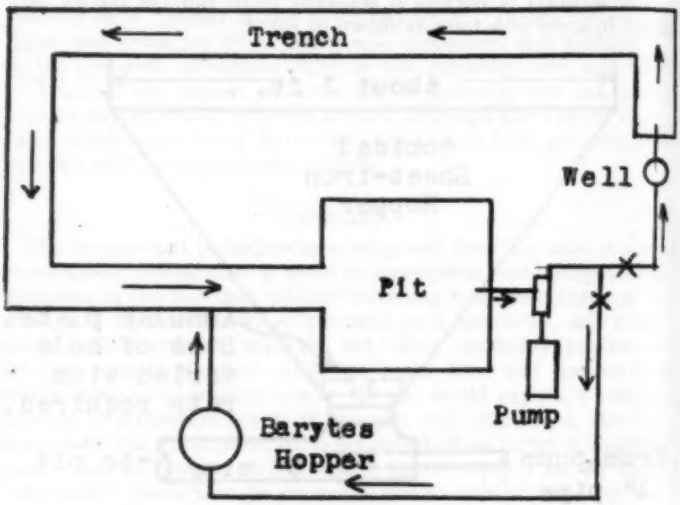


FIG. 5.

To the volume of the mud in the well must be added that in the pit and trenches, etc., and addition of barytes increased proportionately.

The even mixing of the colloid, or soda, is of still greater importance and, generally speaking, it is advisable that they shall be added at a definite rate per second, even if it entails the employment of a man to call or beat out the seconds.

The laboratory should determine the amount of reagent to be added.

One must not rest satisfied with testing weight and viscosity at the central station, but it should be a continuous duty on the rig, and the driller's duplicate report book should include spaces

for tests at regular intervals. Admittedly the taking of viscosities will be inaccurate at the well, but after all they do give the driller a fairly clear indication if anything is seriously wrong, provided always that he looks after his viscometer and spots such snags as blocking the orifice by large particles of solid, or by a clot of gelatinous mud, etc.

In wet climates much trouble has resulted from carelessness in storing barytes. The bags must be kept dry, otherwise the powder tends to become lumpy, quite apart from the question of bags rotting and bursting. Drillers seldom realise that barytes is a comparatively expensive material.

In connection with central mixing and storage plants, care has to be taken that, even when colloidity is good, precautions are enforced to maintain a certain amount of circulation or mixing, as otherwise it is only a question of time before settlement and blockage occur, more especially in the pipes, and against such constrictions as are caused by valves, elbows, etc.

The decision to turn over to "doctored" muds has to be based on practical experience. Probably it is always advisable to employ it when formation pressures exceed 800 to 1,000 lb. per sq. in.; below those figures it depends so much on previous experience of the formation.

Sometimes barytes "doctored" mud is used from the start—but this seems an obvious waste; ordinary mud should be used (and incidentally fulfil the function of plastering absorbent formations) until there is evidence of obstreperous pressure either from behaviour of the well or from local knowledge. Then the ordinary mud should be displaced or flooded out by the "doctored" and stored separately for future use.

To use barytes "doctored" mud to plaster, and to be lost in low pressure formation is sheer waste.

Reconditioning.

The amount of trouble and expense which one is justified in incurring in reconditioning ordinary mud will be governed by the value of such mud. It may be so cheap that there is no reason why it should be reconditioned at all, or, on the other hand, in some areas, there is difficulty in disposing of scrapped muds, and it may at times involve heavy transport charges to dispose of it; then, perhaps, reconditioning would be justified for a very cheap mud.

Reconditioning, whether of ordinary or "doctored" muds, has only recently begun to come into practice. For example, in the autumn of 1930, a well-known American oil journal states:—"There has been little or no work done so far in reclaiming muds."

In this paper it will perhaps suffice to treat methods of reconditioning as one and the same for ordinary and "doctored" muds, but in the case of the latter there is the additional problem of prescribing the reagents to be added or perhaps counteracted in order to bring the mud to standard.

Reconditioning, in the main, consists of removing cuttings, sand, gas; the difficulties of reaching perfection increase in the order of the bodies mentioned. The next step is a matter of prescribing the reagents.

FIG. 6.

OVERSTROM VIBRATING SCREENS AS USED FOR THE SCREENING OF OIL-WELL MUD.

To rely on the old practice of settling is quite out of the question, even for removing cuttings, unless one is employing a very liquid ordinary mud of such low colloidal properties and low viscosity that solids settle quickly and completely. Naturally a high specific gravity materially reduces the rate of settlement; for example, settlement will be slower in a 100 lb. mud than in a 70 lb., if they have the same viscosity. Viscosity has even greater potentialities than has specific gravity for retarding settlement, and the more viscous the slower must be the movement of the settling particles. Colloidity is still more potent than viscosity.

I was much impressed by Lieut.-Col. H. C. B. Hickling's remark that ore dressing methods must ultimately be adopted for recon-

ditioning drilling muds, and this is borne out by the extent to which in America screening has, during the last year, been experimented with and adopted. It would seem desirable that, so far as possible, screening should be done at the well, in order to obviate the pumping of large pieces of solid material any considerable distance; and here it might be mentioned that effective screening does greatly reduce the capacity required in the settling pits, a saving which can be set off against the screening costs when it is remembered that the pits, *per se*, are valueless when the well is finished. A figure of $600,000 is given as being the cost of pits at 800 wells, *i.e.*, $750 per well. Screens, especially the vibrating type, see Fig. 6 (which I am glad to say is of British manufacture), are

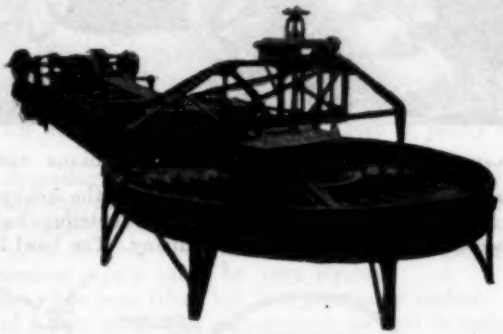


FIG. 7.

DORR BOWL CLASSIFIER.

effective with cuttings and the coarser sand, but a point is reached when, owing to the viscosity and colloidity of the mud, it becomes impracticable for the fine particles, and although meshes as fine as 60 may be used, yet 30 to 40 is generally the limit and thus fine sand is not removed by them.

A further step in the introduction of mining practice, *i.e.*, the use of classifiers and thickeners. The settlings are fed to the centre of the classifier (Fig. 7), from which the grit-free mud flows over the periphery, while the sand is swept towards the centre and discharged into a lower compartment and removed. The grit-free mud then passes to a thickener (Fig. 8) for dewatering. A flow sheet of this method of treatment is shown in Fig. 9.

There, apparently, is no information published as to how far these up to date and mechanical methods for separating sand are successful. It has to be borne in mind that sand as fine as 200 mesh has to be dealt with. Greater success will probably be met

with in the use of some form of centrifuge, at any rate for the final treatment. Here a force of, say, fifty times that of gravity can be applied for driving the particles, but one can conceive that it

FIG. 8.
CLASSIFIERS, THICKENER AND AUXILIARY STORAGE TANKS.

might at the same time effect separation of the heavy barytes. Details have been published (*Oil Weekly*) of a centrifuge having been tried successfully by the Union Oil Company. The bowl is 30 in. in

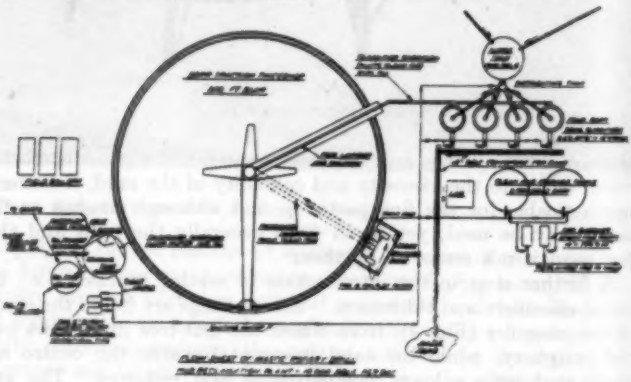


FIG. 9.
FLOW SHEET OF WASTE DRILL IN A MUD RECLAMATION PLANT (10,000 BBL. PER DAY).

diameter and runs at 500 r.p.m.; it is driven by a 10-h.p. motor. The process is continuous, and the rapidity of action is evidenced by the fact that its capacity is up to 300 gallons per minute, *i.e.*,

10,000 barrels per day, under favourable conditions, and it is alleged that separation of sand is effected up to 200 mesh. Details of a run of 82 lb. mud fed at 175 gallons per minute, are given :—

	Feed.	Desanded mud.	Sandy fluid discharged.
Weight per cu. ft.	91·0 lb.	82·0 lb.	100·2 lb.
+65 mesh ..	13·0 per cent.	0·4 per cent.	20·5 per cent.
—65+100 mesh .	19·4 „ „	1·9 „ „	29·6 „ „
—100+150 mesh	3·3 „ „	1·4 „ „	4·6 „ „
—150+200 mesh	6·4 „ „	1·65 „ „	9·2 „ „
—200 mesh ..	3·8 „ „	0·82 „ „	5·5 „ „
Decanted mud ..	54·0 „ „	93·83 „ „	30·6 „ „

and it is claimed that 95 per cent. of the whole of the sand was extracted. It would be interesting to have results of a trial on, say, 110 to 120 lb. barytes mud.

It may be that it will be found ultimately that a drastic form of dilution and levigation would be the most economical and effective method for desanding, provided always there is plenty of water available.

As to degassing, very little seems to have been achieved and, even during the past year, little or no mention can be found of it in the technical press. Generally speaking the driller considers it more of a *bête noire* than sanding and its influence from the economical aspect must be very serious.

Settlement has been tried, but it is practically useless. Indeed, I heard of a case where the management decided to make use of a big accumulation of gassed mud which had been standing on one side in the bottom of a valley more than two years, they feeling confident that the gas would have escaped by the effluxion of time. The surface looked hopeful, so they started digging, but an unfortunate man in a hole a few feet deep decided to smoke, and the resulting explosion killed him. It would therefore appear that settling is entirely out of the question.

Various methods of stirring or agitation, with or without the addition of steam, have been used, but I have never heard of their being really effective.

Screening has been tried by forcing the mud through fine drilling screen-pipe but it has had little effect, and in practice was very troublesome owing to the necessity of repeatedly cleaning the screen. An attempt was made to overcome this by providing a return water flush. Vibrating screens have been used and, although effecting some release, are far from achieving perfection.

Jetting as a fine spray vertically in the air has some effect, but not so much as jetting against a plate. The use of the centrifuge has naturally occurred to many minds, but there is no information

as to trials, successful or otherwise. Running the mud in a thin layer over corrugated sheets has been tested, but with very poor results.

Our laboratory is about to try out two methods which in our experience have been successful in dealing with difficult dirty emulsions, and for that purpose we find that they have the advantages of being convenient and inexpensive. The first is to pass the screened mud between a pair of low-speed rollers, geared so as to have slightly different peripheral speeds, so that as the mud is squeezed it is also submitted to a slight tearing effect. The second method, which might be justified in view of the fact that there is plenty of exhaust steam at a well, is one which we have found effective as a preliminary treatment of oil emulsions which contain very fine solid matter. The mud would be passed down a steam-jacketed inclined pipe, and during its slow passage it would become heated and a certain amount of steam would be given off, carrying with it the gas; gas and steam would come out at the top of the pipe, whilst the degassed mud would flow out at the bottom.

As mentioned above, levigation would appear to give a positive remedy. It seems that in one operation, by suitable dilution, you could get rid of shale, sand and gas. Somehow it appeals as going right back to fundamentals. Whether it should be done simply by diluting with ordinary water, or whether salt water should be used temporarily to neutralise colloidity, is a matter for experiment. In either case the supernatent water would be drawn off and the mud mixed once more, perhaps, with water, and, after settlement, the finer and more desirable solids could be collected from above the sand and the heavy large particles.

On some fields the removal of oil is undertaken, and one hears that it is practicable and profitable. Of this I have no experience, but it would appear that levigation methods might be suitable for the purpose, although one foresees difficulties because it must be more or less common experience that these muds have a peculiar affinity for oil, as they have for petroleum gases, so much so that experiments which I made many years ago showed that Trinidad drilling muds would, in a 2000 ft. column, entirely obscure all traces of almost black oil up to a content of about 30 per cent. This can be easily tested in the laboratory by shaking various proportions of muds and oils and watching their separation.

Having got rid of cuttings, sand, gas and oil, the laboratory can lay down what "doctoring" must be done to bring the mud back to standard.

The governing factor when considering the adoption of "doctored" muds is the cost, and as this is generally high (discussed

later under costs) it imposes on the management another responsibility in exercising special care and adopting precautions and conservation methods and keeping reliable accounts. If the "doctored" mud does not achieve its purpose, it is a regrettable waste of money. The management also have to bear in mind that the geologist, in getting cores, or the driller, in getting footage, does not mind how much he spends and, naturally, neither of them considers it to be his job to bother about finance.

Drawbacks.

I might mention briefly here a few of the snags which accompany "doctored" muds :—

1. High specific gravity and high viscosity decrease the rate of separation of solids.

2. Good colloidity promotes gassing.

3. "Doctored" muds in contact with excessive salt water are dangerous, as owing to accumulation and separation the heavy constituents deposit rapidly and cause blockages.

4. When circulation is stopped, sticking of pipes owing to deposits of heavier solid matter may be more serious than with ordinary mud if the ingredients are unevenly mixed.

5. Muds are much "stolen" by cavities or by porous formations, etc. Cases are on record when, owing to subsequent reduction of pressure, the mud comes out once more into the hole and causes serious trouble in production. I have in mind a recent case, where it took over three months to get rid of the barytes mud that came out in this way.

6. Muds, owing to their plastering effect, may be detrimental to oil production. When considering this point it has to be borne in mind that the mud, when it plasters a porous formation, does not remain as a soft coating. Some dozen years ago I made a crude experiment when we were worried about rotary drilling in a formation where the pressures were not big and where the sands were not prolific, but the oil was of very high value. It was noticeable that, whereas with a percussion drill we had no trouble in getting production, with a rotary we never got production. We took some pieces of sand rock and placed them in a tube capped at both ends, nearly filled the tube with the drilling mud and then pumped up to a pressure of 500 lb., and kept it at that for a week. The tube was opened, the sand rock taken out, thoroughly washed and sections were cut. The sand was penetrated to a depth varying between $\frac{1}{32}$ in. to $\frac{1}{8}$ in., and had thereby been rendered absolutely impervious; in fact, in appearance it seemed to be as

close grained and as hard as slate. No amount of washing had any effect on this crust, and therefore it is no wonder that when washing a rotary well for production the results may be disappointing. Indeed, it would almost seem advisable to take the precaution of running in a reamer to break up the coating or, perhaps, of "shooting" with a small charge for the same purpose.

7. With mud, and specially with "doctored" mud, the driller is given something more to blame, and at the same time something more to go wrong, for after all muds are very sensitive to ill-treatment.

8. Muds call for increase of power in pumping and drilling. However, as in most things in life, "you cannot have it both ways," and although the use of mud has its weak points, yet, when weighed in the balance, there is not the least doubt that it is beneficial and has rendered possible production from and drilling of wells which a few years ago would have been a practical impossibility. As a field manager said to me, "Using mud is a d——d nuisance, but it is a wonderful comfort, and whereas it used to be the exception to bring in one well in five, now it is an exception to fail in one in five, and I get some sleep at nights."

Costs.

There seems to be little or no detailed information available with regard to costs, which after all are the crux of the whole matter. Generally speaking, I found that the management on the fields had realised for some time that the expenditure was inordinately high and that they were hoping that when they had settled down to an organized scheme of making, distribution and re-conditioning, they could face the question of costing and have accurate and happier figures to show. At present there is obviously great wastage, in some cases profligate, and not until costing is instituted and laboratory supervision enforced will the use of mud be put on to a satisfactory basis.

For what they are worth and as some rough indication of costs, I quote certain figures given to me, or published, but which, as no information is given as to whether central station charges, overheads, etc., were included, or whether a well was credited with the used mud which went back for reconditioning, etc., must be treated with considerable suspicion.

With regard to ordinary mud, our company, like many another in Trinidad, is an example of low costs, owing to the presence locally of good mud-making material, not only on the surface but in the wells. We work in a small way and mix at the wells, and we take it that mixing, steaming and screening in batches of 200 barrels

costs some six cents. per barrel, exclusive of the cost of steam which may be one of the larger items. At a central station handling much larger quantities all the costs would be greatly reduced. If the mud is largely made from the formation during drilling, the cost becomes practically nil. On the other hand, in localities barren of clay at the surface and sparse in the well, where the clay has to be imported at a very high charge, the costs mount up. Such figures as $30 to $50 per ton for clay are quoted. Then, again, in some areas water is costly, for example, in Peru.

In the case of "doctored" mud, certain approximate figures emanate from Trinidad. The various informants made the following statements :—

1. A well 3000 feet deep took 150 tons of barytes costing $3300, but some half of this mud was available for the next well. This would mean a net cost of $0.53 per foot. The cost of handling was not included.

2. Consumption of 100 to 150 tons barytes for wells averaging 2500 feet.

3. An average consumption of 40 to 50 tons of barytes for wells averaging 1500 to 1200 feet.

4. In this case 1000 tons of barytes was used for 15 wells, *i.e.*, nearly 70 tons per well.

5. With wells averaging 2000 feet, 120 tons per well.

6. With no depth quoted, consumption varied from 100 to 150 tons per well.

7. Here an average figure of 270 lbs. per foot, or nearly $2.50 per foot.

A rough survey of the above figures, taking barytes at $22 per ton, indicates that the wells consume from $900 to $4000 worth per well, and that this figure averages out at anything from $0.50 to $2.50 per foot. This, generally, on ordinary straight-forward wells which, including the cost of the first string of 11¾ in. casing to a depth of 2000 feet, would, apart from the mud, cost perhaps anything from $12,000 to $20,000, or from $6.0 to $10.0 per foot. The addition of a dollar or two per foot to secure immunity from trouble and to avoid the loss of a well is, after all, but a small increase in the expenditure.

In periodicals appearing this year (1930), the following figures are noted :—

In Oklahoma clay costs from $10 to $50 per ton and consumption varies from 10 to 300 tons per well. In Hobbs, N. Mex Field the consumption is 100 to 300 tons per well. the price

varying from $7 to $55 per ton. Average cost per well for mud is estimated at $10,000.

In Ventura, with 7000 ft. wells: costs now some $15,000 per well but previously, and before the installation of the central reconditioning plant, the cost was more than twice this amount and the mud much inferior.

At Signal Hill, with three wells averaging 7500 feet: ordinary mud came out at $3500 each; the deliveries to wells varied from 5000 to 25,0 0 barrels of 70 lb. mud.

On Kettleman Hills, with wells 4/5,000 feet: for "doctored" mud each well costs about $50,000. In extreme cases, however, they cost more.

Nowhere does there appear to be any published data with regard to the cost in practice of the addition of a colloid, or of soda, etc. It is to be hoped that giving publicity to the paucity of existing information will be the means of bringing something forth. It seems that we want to get at the first cost of the mud, its consumption and the cost of reconditioning, and this with proper allocation of transport, wages, fuel, depreciation, overheads, etc. It will also be interesting to have figures indicating what amount of mud actually disappears into the formation, and keeping this distinct from any that may be wasted at the well head or thrown away because of its deterioration by gas, sand, etc.

Coming again finally to the chemist, do not the facts indicate that there is no question that his assistance is a *sine qua non* to the efficient and economical using of mud?

SIXTH INTERNATIONAL ROAD CONGRESS,

October 6th-11th, 1930.

By P. E. Spielmann, Ph.D., F.I.C., B.Sc., A.R.C.S., A.Inst.P. (Member)*.

The Sixth International Road Congress was held at Washington, D.C., U.S.A., from October 6th to 11th, 1930, when the following questions were discussed :—

First Section.—Construction and Maintenance.

Question 1. Results obtained by the use of (a) Cement; (b) Bricks or other artificial paving.

„ 2. The most recent methods adopted for the use of tar, bitumen, and asphalt in road construction.

„ 3. The construction of roads in new countries and undeveloped regions.

Second Section.—Traffic Administration.

Question 4. Ways and means of financing highways : (a) Road construction ; (b) Maintenance.

„ 5. Highway Transport : Correlation and co-ordination with other means of transport, adaption to collective (organisations) and individual uses.

„ 6. (1) Traffic regulation in large cities and their subways ; traffic signals ; design and layout of roads and adaption to traffic requirements in built-up areas. (2) Parking and garaging of vehicles.

The Resolutions adopted by the Congress relative to Question No. 2, the only one of interest to the Institution of Petroleum Technologists, were the following :—

1. Tar, bitumen (asphaltic bitumen), and asphalt are suitable materials for use in the improvement of all classes of roads, subject to the limitations imposed by the characteristics of the material, the intensity of traffic, and local physical conditions. It is especially desirable to note the extended use in recent years of superficial coatings, in particular those effected with emulsions. Certain governing conditions generally recognised are :

(*a*) The use of the correct grade and amount of bituminous binder for the particular type of work and aggregates to be used.

(*b*) Suitable aggregates, correctly graded.

(*c*) Provision for prompt maintenance. When the foundation is adequate and when the surface can be maintained at reasonable cost, an advantage of the types of roads built with these materials is that they can be kept in good condition by maintenance of the surface without the need of extensive repairs to the foundation.

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* Delegate of the Institution of Petroleum Technologists.

(*d*) Proper proportions of the constituent materials, thorough mixing and thorough compacting.

(*e*) Competent technical supervision of design, construction, and maintenance.

(*f*) Slipperiness. Attention should be given to the reduction of slipperiness. In some cases valuable results have been attained by the following methods :

(i) Adoption of suitable compositions containing the maximum permissible proportions of large aggregate.

(ii) The rolling of plain or precoated chippings into new laid surfaces.

(iii) The use of minimum practicable camber of surface and proper degree of super-elevation on curves.

(iv) Treatment of existing surface with a suitable surface dressing compound, covering with coarse hard chippings, and rolling.

2. The need for research into the fundamental factors involved in the use of tar, bitumen, and asphalt in road improvement and maintenance is recognised. The attention of the members of the Congress is especially directed to needs as follows :

(*a*) Research into the constitutions and characteristics of bituminous materials and their combinations with other materials with proper study of their application in the treatment of earth roads.

(*b*) Improvement of mechanical equipment for use with these materials and their combinations with mineral aggregates.

(*c*) Research into factors affecting the durability and serviceability of roads, such as climate, subsoil, traffic density, and road design.

(*d*) Data on economic factors, such as :

(1) Cost of transportation over various road types, including vehicle operation costs and roadway costs, with proper study of their application in the treatment of earth roads.

(2) Relation between maintenance costs and intensity of traffic for various road types.

3. In order that mutual understanding and helpfulness may be promoted, there is need for an international classification of materials, combinations of materials, construction methods, and road types which will correlate the terms in use throughout the world, both commercial and scientific.

A special call was made for the discussion, at the next Congress, of the problems connected with emulsions. This next meeting will take place in Munich, in 1934.

The Reaction of Olefines with Sulphuric Acid.*

By W. R. Ormandy, D.Sc., F.I.C., F.C.S., M.I.A.E., and E. C. Craven, B.Sc., F.C.S. (Members).

Some recent work by Howes and Nash deals with the action of potassium permanganate on unsaturated hydrocarbons.[1] It was found that the lower olefines are attacked fairly easily, but that higher unsaturateds are very stable. In the same paper it is stated that those unsaturateds stable to permanganate are also *fairly* stable to sulphuric acid.

In an abstract of the above paper[2] the need for compression has resulted in the omission of the italicised word. The impression might thus be given that higher olefines are entirely stable to sulphuric acid.

Considerable work by the present authors[3] makes it exceedingly improbable that any open chain olefine can exist in contact with concentrated sulphuric acid. If ethylene be excepted, the reaction products are invariably saturated hydrocarbons (probably open chain paraffins) which separate from the acid, and highly unsaturated products which remain in solution. It is greatly to be desired that other observers would examine this reaction. In the meantime, however, it was thought advisable to determine the action of various concentrations of sulphuric acid on olefines such as were employed by Howes and Nash in their permanganate experiments. The results will be discussed after the experimental work has been described, but no attempt will be made to discuss other work on this subject.

Experimental.—The authors are indebted to Professor Nash for gifts of trimethylethylene, pentene-2 and diamylenes II and III as actually employed in the experiments with permanganate. In addition, isopropylethylene (b.p. 20–22°) was fractionated from fusel oil amylene, and nonylene (b.p. 135–139°) and dodecylene (b.p. 187–190°) fractions were separated from the oils prepared by the action of phosphoric acid on isopropyl alcohol[4]. A third sample of diamylene was prepared by the action of 80 per cent. sulphuric acid on amylenes, the fraction 149–155° being taken.

* Paper received, September 23, 1930.

[1] *J.S.C.I.*, 1930, **49**, 113T.
[2] *J. Inst. Petr. Techn.*, 1930, **16**, 143A.
[3] *J.S.C.I.*, 1928, **47**, 317T.
[4] *J.S.C.I.*, 1929, **48**, 291T.

The following physical constants were determined for the last three preparations :—

	$d_{20°}$.	$n_D^{20°}$	$_rL$	$_rL$ (theory).
Nonylene ..	0·7348	1·4196	0·3440	0·3432
Diamylene ..	0·7662	1·4356	0·3410	0·3418
Dodecylene ..	0·7668	1·4362	0·3411	0·3398

The olefine under test was diluted to a 10 per cent. volume solution with heavy petroleum spirit (B.D.H. Aromatic free "A.R") and 5 c.c. of this solution pipetted into a 1-inch test tube followed by 10 c.c. of sulphuric acid of the required concentration. This mixture was stirred vigorously by a glass stirrer at high speed for 30 mins. The stirrer was then stopped and the mixture transferred to a small tap-funnel, where it separated into two layers. A known volume of the spirit layer was withdrawn by a pipette and the bromine absorption determined by the Hanus test. The bromine absorption of the original olefine solution was determined also.

The following table gives the results obtained :—

Acid Concentration, per cent...	81·0	86·7	89·7	92·8	97·8	99·5
Olefine.	Per cent. Original Bromine Absorption.					
Isopropylethylene	64	59	41	20	6	4
Pentene-2	52	51	39	17	3	0
,, 2 hours stirring ..	69	62	39	19	4	0
Trimethylethylene	71	58	44	21	3	0
Nonylene	99	63	53	34	5	1
Diamylene	99	87	69	32	4	0
,, II.	99	71	53	29	6	1
,, III.	99	73	52	25	4	0
Dodecylene	100	96	59	24	7	1

In most cases a series was run with a period of 2 hours' stirring. Except in the case of pentene-2, this resulted in a small further reduction of bromine absorption. With pentene-2, however, and the two lowest concentrations of acid, the extra stirring led to a distinctly increased bromine absorption, as shown in the table. This suggests that pentene-2 is dissolved by sulphuric acid, and that the alkyl hydrogen sulphate so formed breaks up again into acid and olefine polymerides.

An inspection of the table shows that in a general way the olefines become more resistent to the attack of sulphuric acid as their molecular weight increases in agreement with the statement of Howes and Nash. The difference in behaviour, however, is only marked at the lower concentrations of acid—say, up to 90 per cent.—higher concentrations reducing the bromine values to very small figures. It would appear also that completely to destroy the bromine absorbing power an acid of full concentration is required, even a concentration of 98 per cent. not being sufficient.

Further to illustrate the fact that a permanganate-resisting olefine, like diamylene, is not stable to sulphuric acid, 50 c.c. of diamylene (b.p. 149–155°) were stirred with 150 c.c. of 98 per cent. sulphuric acid at 20°, and the reaction products allowed to separate by keeping overnight. The lower acid layer, on diluting with water, gave the usual unsaturated "acid wash oils." The colourless oily upper layer showed the following characteristics :—

$d_{20°}$ .. 0·7640
$nD^{18°}$ .. 1·4288
$rL = 0·3374$

Bromine absorption, 6 per cent.
Distillation range, 115–300° (80 per cent. over).

The fall in specific refractivity and change in other characters are fully in accordance with the authors' previous work, and the above characteristics agree with those expected for a mixture of open chain paraffins of the boiling-point range given.

The authors desire to acknowledge the financial assistance received from the Distillers Co., Ltd., and from the Fuel Research Division of the Department of Scientific and Industrial Research towards the expenses of this research.

CURRENT PETROLEUM NOTES.

The following notes regarding petroleum developments in various areas are extracted from papers presented before the Petroleum Division, American Institute of Mining and Metallurgical Engineers, February, 1931 :—

Africa.—In Egypt the Hurghada field now has about 60 producing wells and Abu Durba 15, the latter being a small producer. The total production of the Egyptian fields in 1930 was 277,146 metric tons, an increase of 5,626 metric tons over 1929.

The results of geological work in Somaliland are reported to be unfavourable and the work is to be discontinued.

In Mozambique a well is being drilled at Inyaminga, and is reported to have reached a depth of 2763 ft. Shows of oil are said to have been met with.

A number of prospecting wells have been drilled in Angola, and a deep test located about 60 miles south-east of Loanda has reached 3890 ft.

In the Rharb district of Morocco a well near Ouezzan has been drilled to 935 ft. and small quantities of oil reported.

The production from Algiers in 1928 was 1223 metric tons, obtained from three wells near Medjillah. The oil horizon is at shallow depth, under 500 ft.—(W. B. Heroy.)

Argentine.—The total production of petroleum in the Argentine during 1930 was 8,909,773 barrels (1,415,099·7 metric tons), a decrease of 481,613 barrels from 1929. The production by fields was : Comodoro Rivadavia, 7,274,649 barrels ; Neuquen, 1,358,628 barrels ; Salta, 276,496 barrels.

Petroleum activities have been hindered by Government restriction and monopoly, but there is reason to anticipate that this policy is being supplanted by a tendency to permit private capital and enterprise to enter into the oil industry of the country. A permit has been granted to the Royal Dutch Shell interests to erect a 3500 barrel refinery in Buenos Aires, and an injunction against drilling operations by the Standard Oil Co. of Argentine in the Lomitas field, Salta, has been lifted.—(Gilbert P. Moore.)

Bolivia and Chile.—In Bolivia, five wells have been completed at Sanandita, of which two are producers, and it is reported that a pipe-line is to be laid to the Lomitas field in Argentina. Well No. 9 in the Bermejo field has been completed, but no information as to its production is available.

The Chilean Government has entered into a contract for exploration work to be undertaken in five distinct zones. Geophysical work in the Magallanes region is now also in progress. A Government oil refining monopoly has been created, and covers also the hydrogenation of coal and oil.—(Gilbert P. Moore.)

California.—Significant developments in 1930 were :—

In the San Joaquin Valley discovery of high-gravity oil in the Temblor sands, North Belridge, and in the Kettleman North Dome field ; activity for deeper production in the Lost Hills field ; and the finding of oil in the Margarita sands, Mountain View area.

In the Los Angeles Basin, the finding of a deeper zone on the West Coyote field ; extension of the deep zone in the Long Beach field, and production development of over 48,000 barrels per day at Playa Del Rey.

In the Coastal District developments of the westward extension of the Elwood field into the ocean, and at Capitan, eight miles west of Elwood ; the extension of thickness of the producing zone in the Ventura Avenue field ; proving the extension of the Rincon field into the sea, and finding a probable eastward extension of the Lompoc field.

There has been a continued improvement in drilling technique during 1930, and the world's deepest well was completed near Taft in April to 9629 ft., a string of 5½ in. casing being cemented at about 9350 ft. Pumps in operation at 7500 ft. are common and gas injection has been used in several areas with good results.—(B. E. Parsons.)

Russia.—The total production of oil in Russia during the 1929-30 operating year was 124,000,000 barrels, an increase of 27,200,000 barrels over 1928-29. The five-year plan calls for a production of 330,000,000 barrels in the calendar year 1933, but a study of the conditions existing indicates that this is excessive.

The total oil run to refineries during 1929-30 was 107,000,000 barrels, and in 1928-29 77,500,000 barrels. Gasoline recovery was 19·4 per cent. in Grosny and 5·1 per cent. in Baku. Kerosine was 18·7 per cent. in Grosny and 24·8 per cent. in Baku. The total production of refined products was 103,000,000 barrels in 1929-30, the interior distribution being 76,750,000 barrels, an increase of 30·7 per cent. over the preceding year.—(Basil B Zavoico.)

BOOKS RECEIVED

ON THE DETERMINATION OF THE EMPIRICAL FORMULA OF A HYDROCARBON. E. W. Washburn, Bur. Standards Res. Paper No. 236. Pp. 24. Washington, D.C., 5 cents.

A laboratory procedure is outlined for determining the empirical formula of any pure hydrocarbon containing not more than 100 carbon atoms with the minimum of effort and inconvenience.

COMPRESSIBILITY AND THERMAL EXPANSION OF PETROLEUM OILS IN THE RANGE 0° to 300° C. R. S. Jessup. Bur. Standards Res. Paper No. 244. Pp. 55. Washington, D.C., 15 cents.

Compressibilities and thermal expansions of representative samples were determined over the ranges of 0 to 5° kg./cm.² (gauge) and 0° to 300° C. It was found that, with a knowledge of the specific gravity and viscosity, it was possible to represent all the measured volumes within less than 0·5 per cent. over the ranges of pressure and temperature covered.

REPORTS OF THE PROGRESS OF APPLIED CHEMISTRY. Pp. 745. London: Society of Chemical Industry, 1931. 12s. 6d. (7s. 6d. to Members of the S.C.I.).

This annual volume of Progress Reports has made its appearance much earlier than in previous years, and a detailed review will appear in a later issue of the Journal.

ERRATA.

"Hydrogenation of Petroleum Oils," by Ralph H. McKee and Antoni Szayna. Journal No. 88, page 129, last line: For "$(Al\ Cl_3\ C_4H)_n$" read "$(Al\ Cl_3\ C_4\ H_x)_n$."